

Hi-Rel Integrated Circuit Packaging Development

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Standardized modular hardware for the packaging of DSIF integrated circuit logic systems is described. The status of development is reported and a schedule given for the production of station-quality hardware.

I. Introduction

The standardized packaging hardware provides for the packaging of complete integrated circuit (IC) logic systems for mounting in a DSIF standard rack. A brief introductory description of the hardware is followed by a discussion of the requirements for DSIF hardware and related goals. A more detailed description of the hardware is then given. The current status is described, and schedules are given for the procurement of station-quality hardware.

The basic integrated circuit module is the dual-in-line (DIL) package available commercially (Fig. 1). The version to be used by the DSIF is hermetically sealed in ceramic and glass, which can be purchased under hi-rel specifications to MIL-883 procedures. These modules plug into the subchassis shown in Fig. 2. Interconnections are made by miniature wire-wrap, 0.64-mm (0.025-in.) square posts on a 2.54-mm (0.1-in.) grid (or integer multiples thereof). The Navy Standard Hardware Program (Naval Avionics Facility, Indianapolis) uses this wire-wrap in Polaris submarines and other projects, thus several commercial sources are available with hi-rel experience. Both fully automatic and semiautomatic wire-wrapping machines are in use by numerous suppliers of contract services. Discrete components are rapidly becoming available in DIL modules physically compatible with the IC

modules; thus, it is possible to interconnect special interface circuits with wire-wrap, as an alternative to special modules. Discrete components can also be mounted on DIL headers.

For large systems, a main chassis is available (Fig. 3) which holds eight of the plugable subchassis. If only one or two subchassis are required (perhaps closely integrated with other equipments), a smaller chassis can easily be assembled. Interconnection on the main chassis is by heavy-duty wire-wrap, 1.14-mm (0.045-in.) square posts on a 5.08-mm (0.2-in.) grid. This grid includes compatible cable connectors for cabling to other equipments both internal and external to the rack. Two of these main chassis may be mounted side by side, as shown in Fig. 4, with slides for accessibility. The vertical orientation of the subchassis provides for the maximum utilization of rack-cooling air without resorting to auxiliary fans.

This packaging hardware evolved from the following DSIF requirements (a complete statement was provided to the technical and managerial review committees; it is abstracted here). The modules were to be packaged into plugable subchassis which would facilitate station maintenance, and which would be ruggedized for ease in handling and shipping. The main-chassis interconnections accessible to station operating personnel should be rea-

sonably rugged, not easily damaged by scope probes, etc. Considerable emphasis was placed on reliable repair of the subchassis, and in its capacity to accept modifications without degradation of reliability. The hardware must be procurable from multiple sources so as to meet government requirements for competitive bidding while retaining interchangeability of all parts from one procurement to the next.

The packaging hardware should be designed so that it could be stocked in a form which could be assigned or re-assigned to the broadest possible spectrum of users. It should accommodate MSI (medium-scale integration) and LSI (large-scale integration) modules as they become available.

However, the assembly effort required of the user should not be excessive, in the interest of ease in system prototyping. Even though the hardware could be stocked, it was felt necessary to minimize the procurement time for parts, recognizing the occasional short lead time between the availability of funds and project completion. This goal seemed to indicate that the hardware should utilize parts similar to available commercial items.

The requirements and goals given above were gaged to be of sufficient value to the DSIF (including long-term cost savings relating to user factors) that the original cost of the hardware could exceed that of commercial practice by a significant amount. That is, we were not bound as severely by the need to meet a competitive sale price, regardless of eventual user costs.

Of course, these requirements and goals had to be evaluated in relation to the functional/electrical requirements. It was decided that the initial effort should accommodate at least 20-MHz clock rates. The system should provide a good ground plane to facilitate the interconnection of a large number of ICs without unnecessary use of twisted pairs. An effort should be made to carry the subchassis ground plane through the main chassis, as well as could be accomplished across a plugable interface. A power distribution plane should be provided on the subchassis which would eliminate the need for a bypass capacitor for each IC.

All hardware had to be evaluated for its reliability. The goal was to hold the incidence of module interconnection failure to no more than 10% of the IC device failure (interconnection failures internal to the DIL modules are included in the device failure category).

II. Detail Description

The subchassis shown in Fig. 2 is an aluminum extrusion. It provides the necessary ruggedness. The connector blades are recessed in a protective channel, and, with the covers off, the chassis can be laid on a flat surface without striking the wire-wrap pins or IC modules. The IC modules are mounted as follows. The chassis is extensively drilled with holes on a 2.54-mm (0.1-in.) grid. Contact receptacles for the DIL IC module pins are gold-plated stampings integral with a wire-wrap post. They are inserted in nylon bushings which are in turn press-fitted into the holes in the aluminum chassis. The parts shown in Fig. 5 are commercially available. The rationale for the selection of the contact, nylon bushing, holes-in-a-metal-plate technology is modularity and repairability. New contacts can be inserted in the nylon bushings without removal of the bushings and the bushings are readily replaceable. The array of holes in the metal plate permits the use of any size module, if its pins are disciplined to 2.54-mm (0.1-in.) centers, or integer multiple thereof. Drilling of the necessary holes is done by a tape-controlled machine. Contract services are widely available and the cost is not excessive considering the benefits in modularity and ease of repair.

The contacts shown in Fig. 5 are considerably heavier and have greater retention force (50 to 140 grams (2 to 5 oz)) than the contacts used in the typical commercial one-piece molded socket. Most of the shortcomings of these commercial sockets are due to design criteria which emphasize low cost. Secondly, they are designed with low-insertion force for ease of module insertion. The receptacles to be used by the DSIF require a tool (available commercially) to guide the IC module pins into the receptacle.

The subchassis receptacle pattern is divided into four identical sections; within each section, there are 35 contacts per row. Sectioning was necessary to accommodate the jackscrews, but also permits the power plane to be sectioned. Thus, a row will accept a DIL module with up to 35 pins in a line, or any mixture of modules whose single in-line pin count adds up to 35 or less (note that some modules will not abut end-to-end without wasting one pin). Note that some rows of holes do not have pins installed initially. These rows may be used for the attachment of ground pins as shown in Fig. 6. Alternatively, additional receptacles can be installed in these holes, accommodating any DIL modules whose pin rows are on centers of any integer multiple of 2.54 mm (0.1 in.), such as the 24-pin MSI package currently available (the standard layout accepts modules whose pin rows are on 7.6-mm

(0.3-in.) centers). Connections between the grounded wire-wrap post and the IC module post to be grounded can be made by wire-wrap; however, the use of a metal clip is preferred (Fig. 7). Most modules contain several circuits, and common ground inductance will degrade their noise margins. A power plane is insulated from the chassis. Fingers of the power plane pass down between the rows of wire-wrap pins as shown in Fig. 7. Wire-wrap pins attach to the power plane in the same manner as ground pins attach to the chassis. Matching holes in the chassis clear the heads of the power pins (Fig. 8). The power plane may be divided into separate parts, one for each of the four pin receptacle groupings, or other patterns.

The subchassis to chassis connector terminates inside the subchassis with wire-wrap posts. The connector is modular; each group of three pins is a separate module which fits into a slot in the subchassis. Figure 9 shows a connector module removed from its slot. If a blade or wire-wrap pin is damaged, the respective module is replaced individually. Modification of the logic, as well as repair, is enhanced by the solderless nature of the interconnect. Special repair tools are a torque wrench (preferably of the preset torque-limit type) and a hollow rod for pushing out wire-wrap posts.

The subchassis is mated with the main chassis with the aid of guide pins and jackscrews. The sequence of mating is the guide pins, the jackscrews, and the connector blades. Receptacles on the main chassis use the same technology as the subchassis. However, the main chassis uses heavier wire-wrap posts and larger connector blades on 5.08-mm (0.2-in.) centers. Whereas the 0.64-mm (0.025-in.) wire-wrap posts on the subchassis are easily bent and perhaps broken by test probes, the 1.14-mm (0.045-in.) posts used on the main chassis readily tolerate scope probes and clip leads. The use of 5.08-mm (0.2-in.) centers on the main chassis provides adequate interconnection density. Grounding on the main chassis is accomplished by replacing the insulated bushings with metal bushings. However, an auxiliary strip of grounded posts can be mounted on the chassis; one such strip is shown in Fig. 3. A power plane is not required. Typically, one subchassis will draw five amperes, and at least one pair of wires will be required between each subchassis and the power supply. Tantalum capacitors should be located at each subchassis connector to bypass medium-frequency switching transients.

The main-chassis technology is easily adaptable to smaller systems. Fabrication of a smaller main chassis proceeds by cutting an aluminum plate of the desired

dimensions (preferably with rolled edges or mounted on angle stock for stiffening), drilling the necessary holes, and inserting the contact-bushing sets. A tape for automated drilling requires about one-half day to prepare. JPL has a tape-controlled drill available for prototypes and the contacts will be stocked.

Chassis contacts that mate with the cable connector are identical with those which mate with the subchassis, and the chassis provides 20 connectors of 45 pins each. The development of suitable hardware for supporting the cabling as the chassis slides out to its extended (service) position presented considerable engineering difficulty, because of the large number of wires to be accommodated (1800 with two chassis mounted side by side). Figure 10 shows an assembly of 5 flat cables with cable support hardware. The heart of the cable support is a length of flat spring steel 7.6 cm (3 in.) wide formed into an accordion shape. The cables are attached to the spring with nylon clips. Mounting supports at each end of the accordion spring introduce a small twisting torque which prevents the cable from sagging when fully extended. The cables may contain any mixture of wires, including twisted pair and coax. The desired wires are formed into a flat cable by coating with a plastic material. This process is available from a commercial vendor. There appears to be no reason why a number of round cables cannot be supported by the same accordion spring, although it has not been tried to date.

III. Status

The various photographs show engineering model hardware. One main chassis, five subchassis and one assembly of 5 cables have been procured. The cable assembly has been tested in a rack for 1500 extensions without failure. Both contact types have been tested for 500 insertions and withdrawals; tests on the subchassis to chassis connector were performed on 200 contacts mounted on a test fixture having a configuration similar to, but not identical with, the pictured hardware. Contact resistance changed only slightly and the gold plating did not wear through. Parts for the engineering models were made to JPL drawings representative of those which will be used to procure production hardware. Preliminary specifications have been written covering the requirements for all contacts. Quality assurance specifications covering the manufacture of reliable contacts will be completed in the near future. Future effort will include the completion of assembly documents. Keying procedures will be provided so that subchassis and cable connectors cannot be mislocated. Several techniques that will aid in the location of IC

modules on the subchassis and in logic circuit troubleshooting are being considered. The most promising concept is alternate blocks of colored nylon bushings, in groups of five, plus row and column numbers lettered on the subchassis edges.

Drawings are presently being revised to accommodate a number of minor changes. The clearance holes in the subchassis for the heads of the power distribution pins are being changed from an oval to a round shape. Oval holes were used to permit a power pin to be installed adjacent to any DIL pin, which are on 2.54-mm (0.1-in.) centers. The round holes will be drilled on 5.08-mm (0.2-in.) centers at significantly reduced cost. A potential location for power pins at every other DIL pin will slightly reduce the layout flexibility if bus clips are used for interconnections. There is no loss of flexibility if power connections are wire-wrapped. Another change is a provision for some grounded terminal posts on the module side of the subchassis, which will be used for the installation of small high-frequency bypass capacitors connecting from power plane to ground. It has been found experimentally that 25 of these capacitors reduce the effects of power plane noise to negligible proportions. The original plan had been to install them on the wrap-post side, a procedure which is somewhat awkward and unsightly.

One of the design goals required carrying the subchassis ground plane across the connector to the main chassis, so that large numbers of logic signals can be carried between adjacent subchassis without individual ground wires for

each signal. A test was conducted which showed that the use of five or even ten connector pins for this purpose was inadequate, due to their path length. A connector module with a metal body is being designed which will provide a direct ground.

IV. Production Hardware

Prototype hardware will be fabricated partly to check the drawings, and partly to provide hardware for prototyping new DSIF subsystems. Production part deliveries will commence in July 1972. Parts will be ordered on a competitive bid basis from vendors specializing in the various technologies. Subchassis part procurements will be divided as follows:

- (1) Aluminum extrusion (subchassis).
- (2) Machined and stamped parts (subchassis machining, jackscrews, power plane).
- (3) Electrical contacts.

The main chassis is procurable from vendors who are set up to fabricate complete wire-wrap panels of this type on a custom basis.

The subchassis will be sent to the contact vendor for the installation of DIL module receptacles; remaining assembly operations will be handled by the various contractors who receive the contracts for DSIF subsystem assembly, checkout, and other technical support.

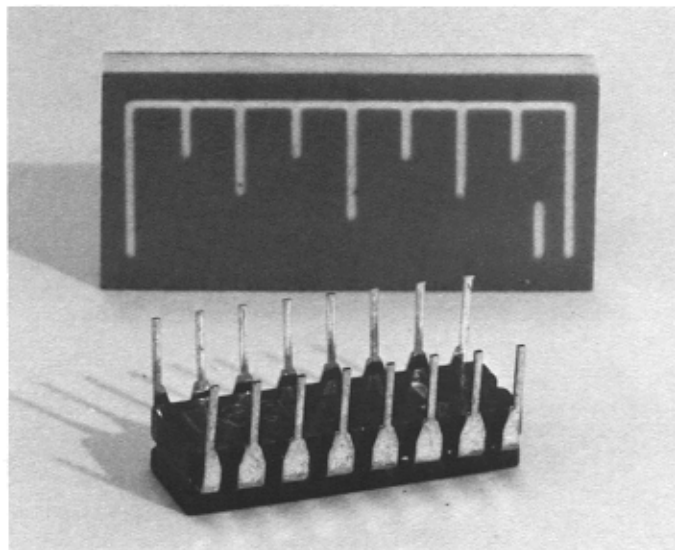


Fig. 1. Dual-in-line integrated circuit module

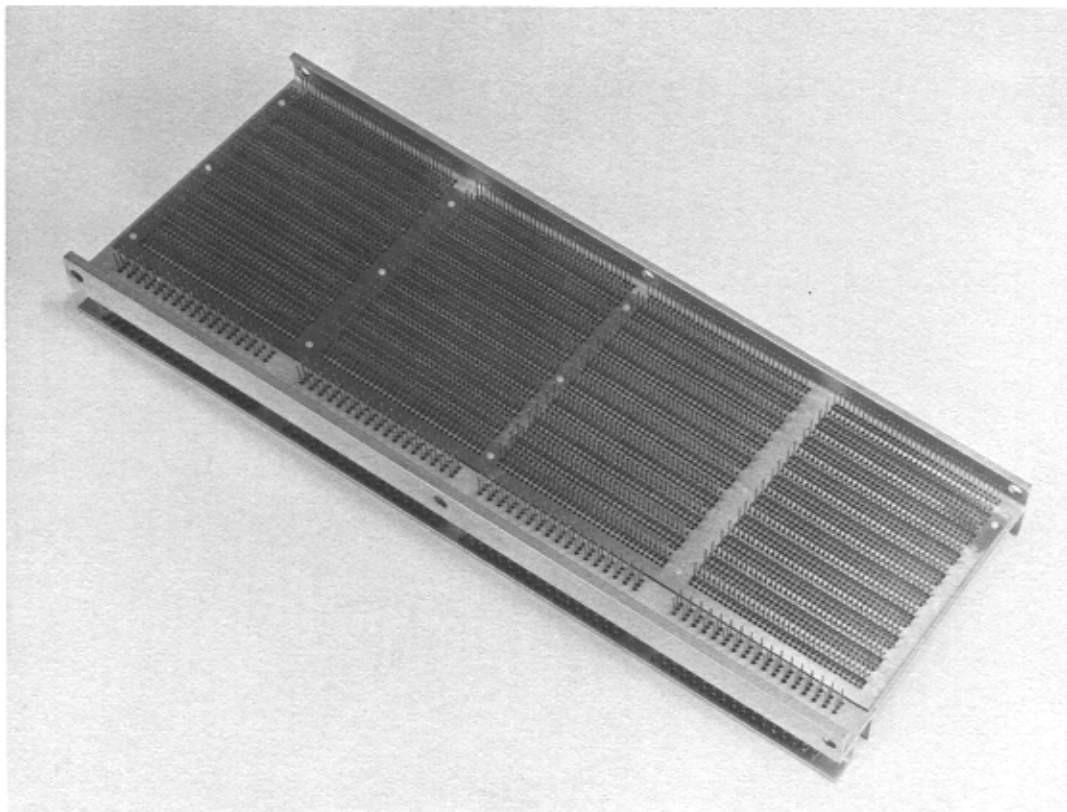


Fig. 2. Front and rear views of subchassis: holds 144 14- or 16-pin DIL modules; accepts any module with pins disciplined to 2.54-mm centers or integer multiples; jackscrews not installed

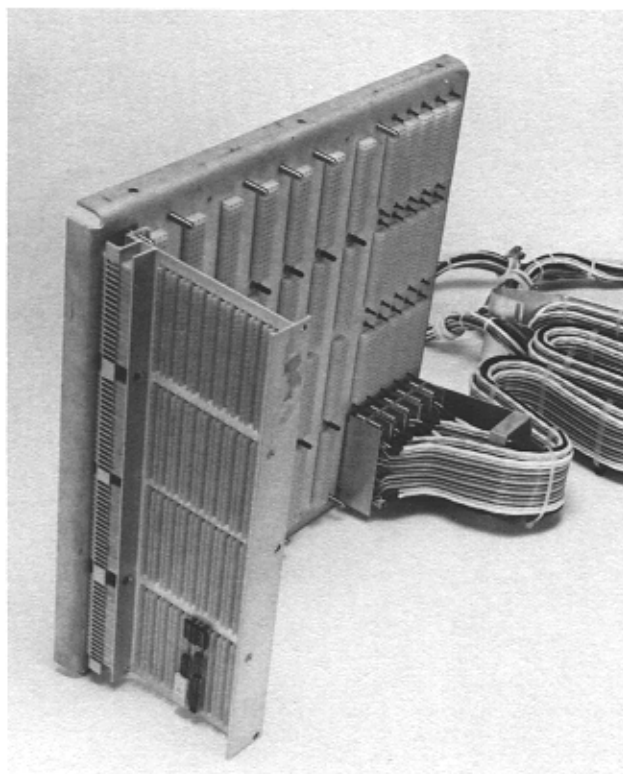
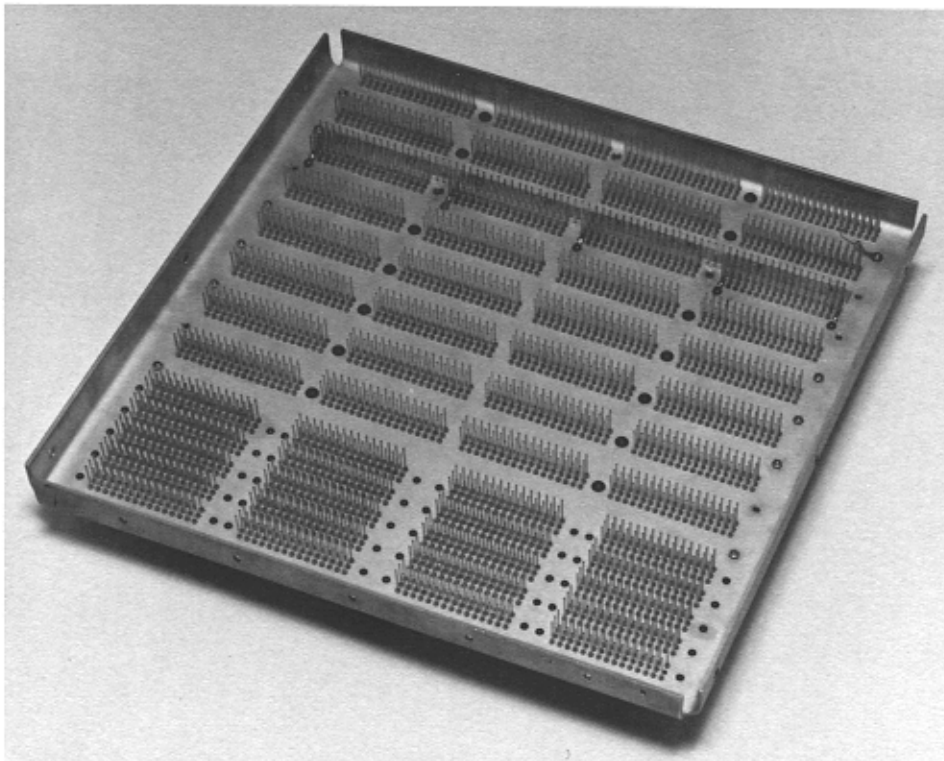


Fig. 3. Front and rear views of main chassis

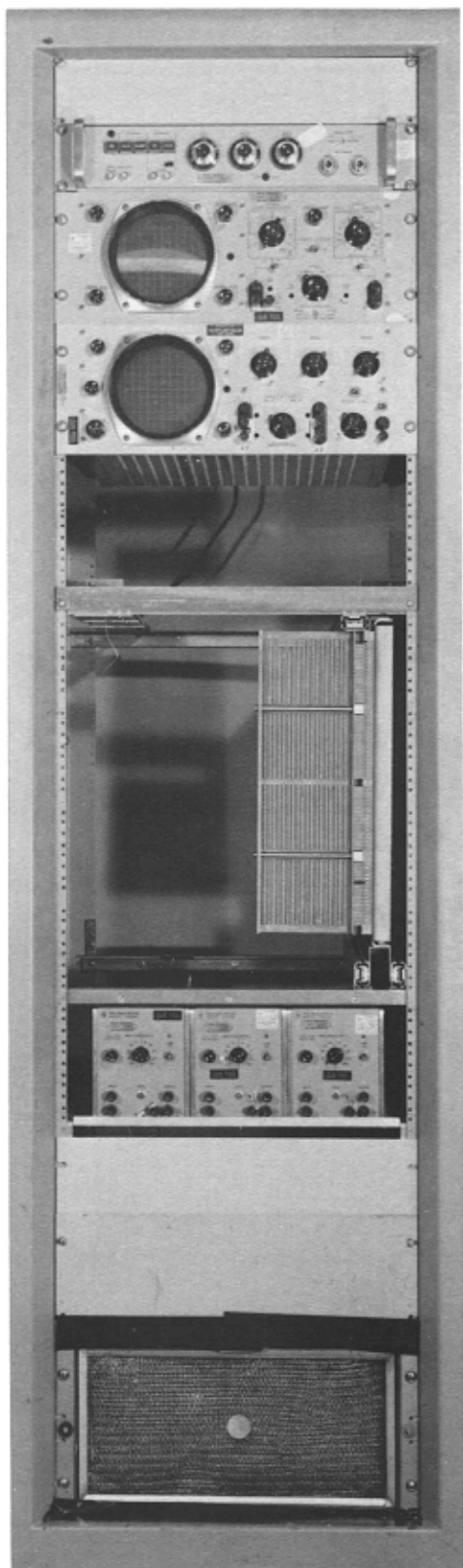


Fig. 4. Rack mounting

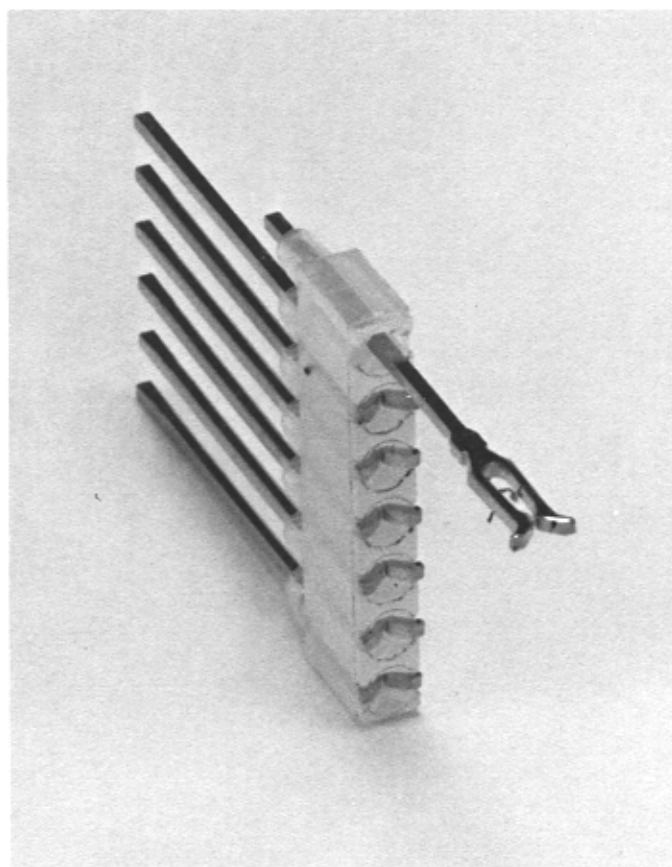


Fig. 5. DIL contact receptacles

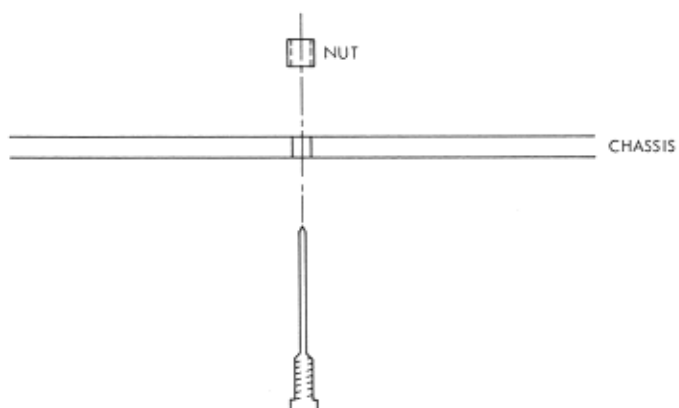


Fig. 6. Ground pin attachment

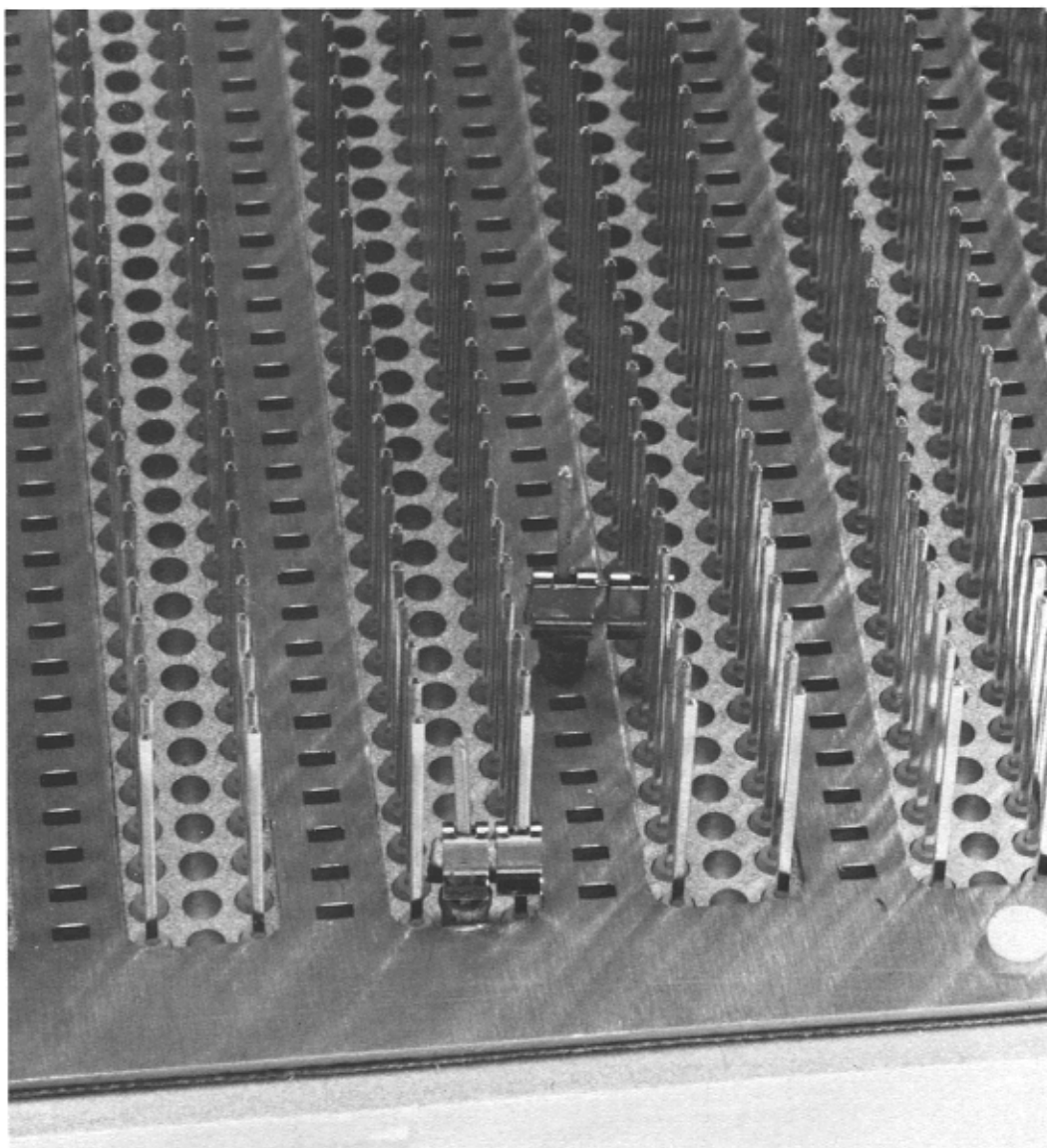


Fig. 7. Bus clip installation: bus clips provide ground and power connections to IC; power plane also visible

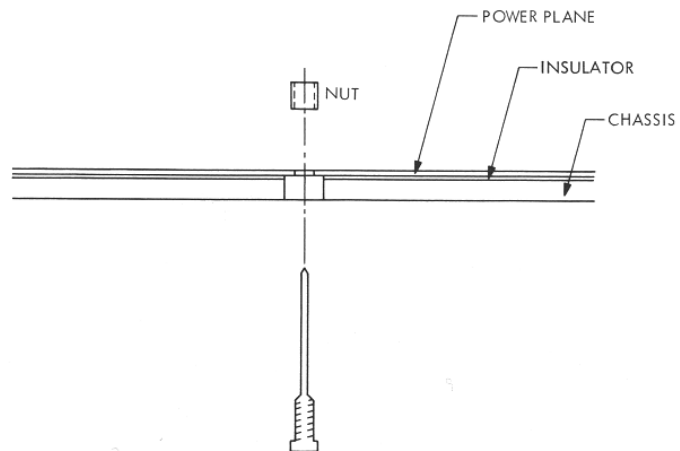


Fig. 8. Power pin attachment

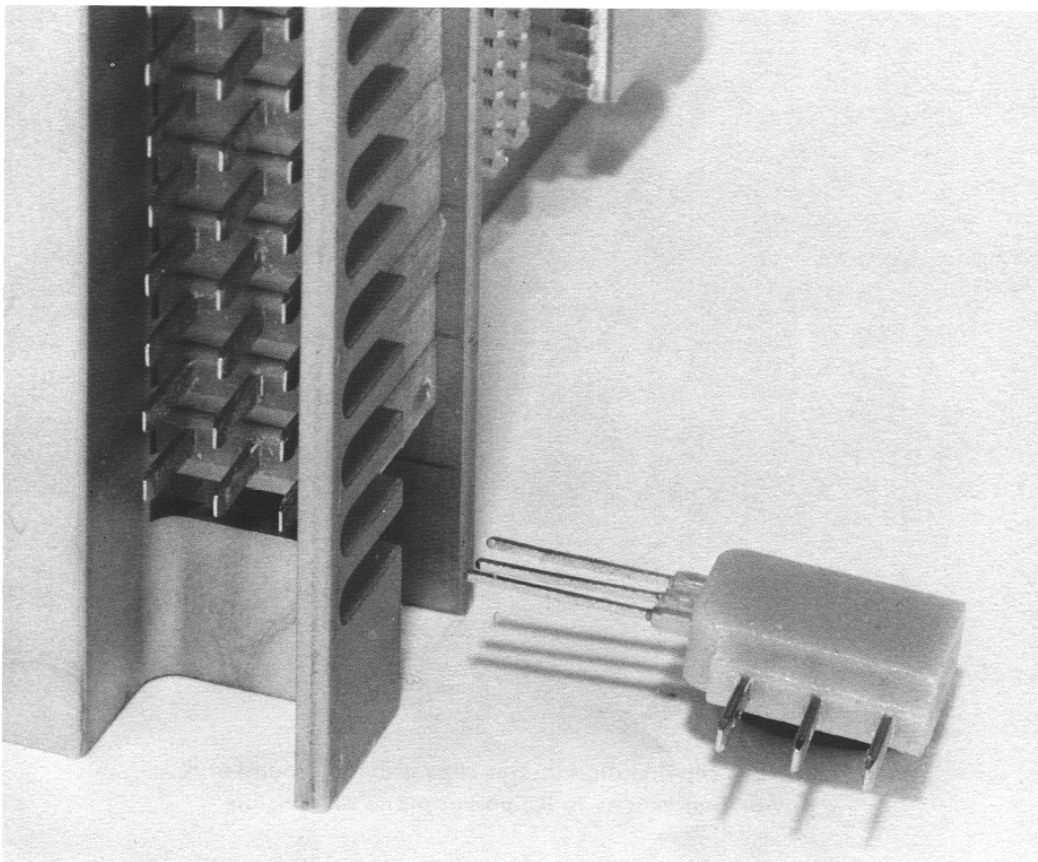


Fig. 9. Connector module

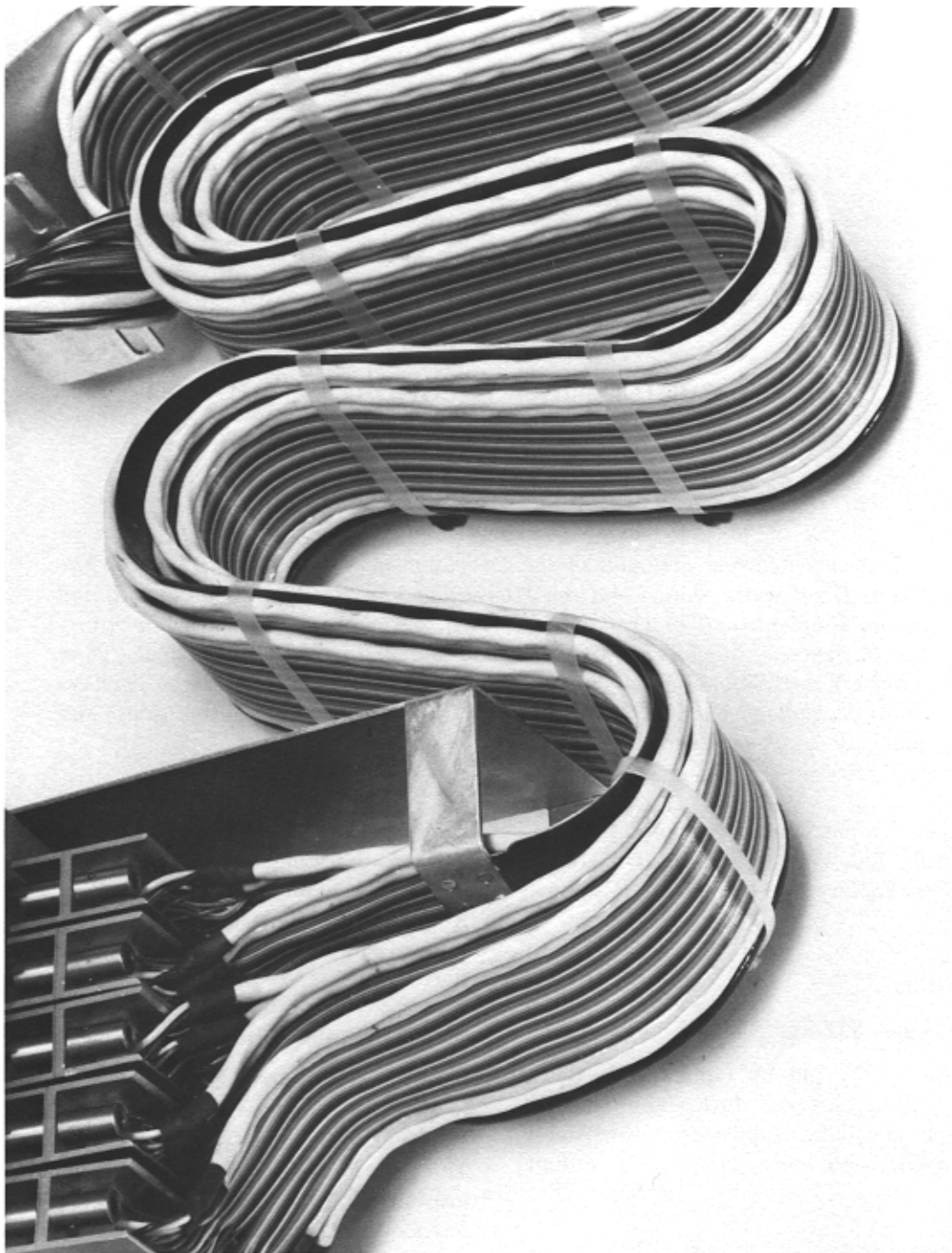


Fig. 10. Accordion cable